CLAIMS

1. A phase contrast system for synthesizing an output electromagnetic field u(x”, y”, z”), comprising

a first phase modifying element for phase modulation of an input electromagnetic field by phasor values $e^{i\phi(x,y)}$,

first Fourier or Fresnel optics for Fourier or Fresnel transforming the phase modulated electromagnetic field positioned in the propagation path of the phase modulated field,

a spatial filter for filtering the Fourier or Fresnel transformed electromagnetic radiation by

in a region of spatial frequencies comprising DC in the Fourier or Fresnel plane

phase shifting with a predetermined phase shift value θ the modulated electromagnetic radiation in relation to the remaining part of the electromagnetic radiation, and

multiplying the amplitude of the modulated electromagnetic radiation with a constant B, and

in a region of remaining spatial frequencies in the Fourier or Fresnel plane,

multiplying the amplitude of the modulated electromagnetic radiation with a constant A,

second Fourier or Fresnel optics for forming an electromagnetic field o(x’, y’) by Fourier or Fresnel transforming the phase shifted Fourier or Fresnel transformed electromagnetic field, and

a second phase modifying element for phase modulating the electromagnetic field o(x’, y’) into the electromagnetic field $o(x', y')e^{i\Psi(x', y')}$ propagating as the desired output electromagnetic field $u\left(x'',y'',z''\right)$.

2. A phase contrast system according to claim 1, wherein at least one of the first and second phase modifying elements is further adapted for phase modulation by first phasor values for a first polarization and second phasor values for a second orthogonal polarization of the input electromagnetic field.

3. A phase contrast system according to claim 2, wherein the second phase modifying element is further adapted for phase modulation by first phasor values $e^{i\Psi 1(x', y')}$ for a first polarization and second phasor values $e^{i\Psi 2(x', y')}$ for a second orthogonal polarization of the input electromagnetic field.

4. A phase contrast system according to claim 2 or 3, further comprising an element for directing the phase modified orthogonal fields into separate paths of propagation, e.g. to be applied in a non-interfering counter-propagating geometry.

5. A phase contrast system according to any of the preceding claims, wherein

$$A = 1.$$

6. A phase contrast system according to any of the preceding claims, wherein

$$B = 1.$$

7. A phase contrast system according to any of the preceding claims, wherein

$$\theta = \pi.$$

8. A phase contrast system according to any of the preceding claims, wherein the phasor values $e^{i\phi(x,y)}$ of the first phase modifying element and the phase shift value θ substantially fulfil that

$$o(x',y') \cong A\left[\exp\left(i\tilde{\phi}(x',y')\right) + K\left|\overline{\alpha}\right|\left(BA^{-1}\exp(i\theta)-1\right)\right]$$

wherein

A is an optional amplitude modulation of the spatial phase filter outside the zero-order diffraction region,

B is an optional amplitude modulation of the spatial phase filter in the zero-order diffraction region,

$\overline{\alpha} = \left|\overline{\alpha}\right|\exp\left(i\phi_{\overline{\alpha}}\right)$ is the average of the phasors $e^{i\phi(x,y)}$ of the resolution elements of the phase modifying element, and

$\tilde{\phi} = \phi - \phi_{\overline{\alpha}}$, and

$K = 1 - J_0(1.22\pi\eta)$, wherein

J_0 is the zero-order Bessel function and

η relates the radius R_1 of the zero-order filtering region to the radius R_2 of the main-lobe of the Airy function of the input aperture, $\eta = R_1 / R_2 = (0.61)^{-1} \Delta r \Delta f_r$.

9. A phase contrast system according to any of the preceding claims, wherein the phase shift value θ substantially fulfills the equation

$$K|\bar{\alpha}| = \frac{1}{2|\sin\theta/2|}$$

10. A phase contrast system according to any of the preceding claims, wherein at least one of the first and second phase modifying element comprises a complex spatial electromagnetic field modulator that is positioned in the path of the input electromagnetic field and comprises modulator resolution elements (x_m, y_m), each modulator resolution element (x_m, y_m) modulating the phase and the amplitude of the electromagnetic field incident upon it with a predetermined complex value $a_m(x_m, y_m)e^{i\varphi(xm, ym)}$.

11. A phase contrast system according to any of the preceding claims, further comprising a light source for emission of the input electromagnetic field, the light source comprising a laser array, such as a VCSEL array.

12. An optical micro-manipulation or multi-beam optical tweezer system according to any of the preceding claims.

13. A laser machining tool according to any of the preceding claims.

14. A method of synthesizing an output electromagnetic field u(x”, y”, z”), comprising the steps of

phase modulating an input electromagnetic field by phasor values $e^{i\phi(x,y)}$,

Fourier or Fresnel transforming the phase modulated electromagnetic field,

filtering the Fourier or Fresnel transformed electromagnetic radiation by

in a region of spatial frequencies comprising DC in the Fourier or Fresnel plane

phase shifting with a predetermined phase shift value θ the modulated electromagnetic radiation in relation to the remaining part of the electromagnetic radiation, and

multiplying the amplitude of the modulated electromagnetic radiation with a constant B, and

in a region of remaining spatial frequencies in the Fourier or Fresnel plane,

multiplying the amplitude of the modulated electromagnetic radiation with a constant A,

forming an electromagnetic field o(x', y') by Fourier or Fresnel transforming the phase shifted Fourier or Fresnel transformed electromagnetic field, and

phase modulating the electromagnetic field o(x', y') into the output electromagnetic field o(x', y')$e^{i\Psi(x', y')}$) propagating as the desired output electromagnetic field $u(x",y",z")$.

15. A method according to claim 14, further comprising the steps of

dividing the electromagnetic field o(x',y') into pixels in accordance with the disposition of resolution elements (x, y) of a first phase modifying element having

a plurality of individual resolution elements (x, y), each resolution element (x, y) modulating the phase of electromagnetic radiation incident upon it with a predetermined phasor value $e^{i\phi(x,y)}$,

calculating the phasor values $e^{i\phi(x,y)}$ of the phase modifying element and the phase shift value θ substantially in accordance with

$$o(x',y') \cong A\left[\exp\left(i\tilde{\phi}(x',y')\right) + K\left|\overline{\alpha}\right|\left(BA^{-1}\exp(i\theta)-1\right)\right]$$

wherein

A is an optional amplitude modulation of the spatial phase filter outside the zero-order diffraction region,

B is an optional amplitude modulation of the spatial phase filter in the zero-order diffraction region,

$\overline{\alpha} = \left|\overline{\alpha}\right|\exp\left(i\phi_{\overline{\alpha}}\right)$ is the average of the phasors $e^{i\phi(x,y)}$ of the resolution elements of the phase modifying element, and

$\tilde{\phi} = \phi - \phi_{\overline{\alpha}}$, and

$K = 1 - J_0(1.22\pi\eta)$, wherein

J_0 is the zero-order Bessel function, and

η relates the radius R_1 of the zero-order filtering region to the radius R_2 of the main-lobe of the Airy function of the input aperture, $\eta = R_1 / R_2 = (0.61)^{-1} \Delta r \Delta f_r$,

selecting, for each resolution element, one of two phasor values which represent a particular grey level, and

supplying the selected phasor values $e^{i\phi(x,y)}$ to the respective resolution elements (x, y) of the first phase modifying element, and

supplying selected phasor values $e^{i\psi(x',y')}$ to respective resolution elements (x', y') of a second phase modifying element having a plurality of individual resolution elements (x', y'), each resolution element (x', y') modulating the phase of electromagnetic radiation incident upon it with the respective phasor value $e^{i\psi(x',y')}$ for generation of the output field $o(x', y')e^{i\Psi(x', y')}$.